RESEARCH DEPARTMENT

VARIATIONS IN THE TROPICAL SUNSET FADING EFFECT OVER THE U.K./SINGAPORE AND U.K./JOHANNESBURG BROADCAST CIRCUITS

Report No. K-146

(1960/14)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

An investigation has been made, from the "fading" data in the reception log-sheets received from Singapore and Johannesburg, of the incidence of the tropical sunset fading effect at those places during the period from local sunset to five hours thereafter, for the equinoctial months of the years 1953 to 1958.

At Singapore the effect was of little consequence during sunspot minimum years, but from 1955 to 1958 it became increasingly noticeable as the sunspot number increased towards maximum. At Johannesburg, on the other hand, it was present even during sunspot minimum years, though its incidence increased considerably from 1955 towards 1958.

At Singapore, during the years when it was present, medium-rapid or worse types of fading set in at local ground sunset and increased to incidence rates of up to 95% of the total hourly observations one to two hours after sunset, thereafter decreasing to a negligible incidence rate four to five hours after sunset.

At Johannesburg the diurnal time pattern was different, and the fading did not generally start until two hours after local ground sunset, thereafter increasing sharply to incidence rates near 80% of the total hourly observations at four hours after sunset, and maintaining a high incidence rate until reporting ceased, five hours after sunset.

1. INTRODUCTION

It was reported by Osborne in 1951[1] that around sunset the F_2 layer at Singapore frequently disintegrates into clouds of ionisation, and that, under these conditions, reflected signals show rapid and intense fading. This phenomenon, which had previously been observed at Huancayo in 1938, appears, in fact, likely to occur at any place near the magnetic equator shortly after sunset on certain days. In a later communication[2] Osborne considered it possible that the effect might be present on some days at all places where the magnetic dip does not exceed about 25°. He stated that, at Singapore, the effect is most frequent at the equinoxes, between 1900 and 2100 LT, and that there is some reason to believe that its frequency of occurrence is greatest at the maximum of the solar cycle. In practice, he stated, the fading results in reflected signals from the F_2 region often becoming unintelligible, even though the signal strength may be high. In 1957 Hitchcock[3] reported that on fifteen of the circuits operated by Cable and Wireless Ltd., where the transmission paths traversed low latitudes, severe fading sufficient to degrade or interrupt the service had occurred, shortly after local sunset, with an average duration of one to one-and-a-half hours. The effect had not been noticeable during sunspot minimum years, but had become so during the last five months of 1956. The relevant "control points" for the fifteen circuits are given, and lie within ±12° of the geomagnetic equator. Humby[4] has reported propagational difficulties on the Admiralty Singapore/London and Colombo/London circuits near local sunset at Singapore and Colombo, respectively, and considered that these were "peculiar to the equinox as distinct from the solstice" and occurred for about two hours after local sunset at the equatorial terminals. He described the circuit failures as being directly related to the phenomenon observed by Osborne, and showed that they were much worse during years of high, rather than of low, solar activity.

Observations made by the B.B.C. in various parts of Africa have confirmed the fact that, on some days, more or less severe rapid fading (usually of the flutter type) sets in after local ground sunset, which has the effect of degrading the broadcast service to the extent that speech becomes unpleasant to listen to though not unintelligible, whilst music is so distorted as to lose completely its programme value.

The incidence of this effect in so far as it affected broadcast reception from the U.K. in Singapore[5] and Johannesburg[6] during 1956 has previously been investigated, and it was found that the fading was such as to degrade the service given in Singapore between 1130 and about 1430 GMT (1830 and about 2130 LT) and in Johannesburg between 1830 and 2100 GMT (2030 and 2300 LT) at which later time reception reports from Johannesburg ceased.*

The aim of the present investigation was to discover whether there is any variation in the incidence of the sunset fading effect in broadcast reception at Singapore and Johannesburg over a period of several years during which sunspot activity increased from a low to a high value, to find out whether there is any difference in the effects as between the two circuits, and to attempt to find anything about the effect which would be of significance in indicating the geographical limits of the area of ionospheric disturbance which gives rise to the fading effects.

2. METHOD OF ANALYSIS

2.1. Data Used

The data used were obtained from the weekly reception logs compiled from observations on B.B.C. transmissions at the Woodleigh (Singapore) receiving station of the B.B.C. Far Eastern Station and at the Panorama (Johannesburg) receiving station of the South African Broadcasting Corporation. These give, for each day of the week, graphs of the results obtained during the period of observations, in terms of the five units of the SINPO signal reporting code.[7] Since the main aim of the investigation was to discover any long-term variations, the logs were examined for the years 1953 to 1958 inclusive, but, in order to reduce the labour involved, only for the months March and September of each year, when, according to most of the evidence, the sunset fading effect should be more frequent than at other times of year.

*The Local Time quoted for Singapore in this report is that for the 105th meridian, i.e. GMT + 7 hours, and the Local Time quoted for Johannesburg is that for the 30th meridian, i.e. GMT + 2 hours.

The incidence of the effect was studied by examining, for each station, the log-sheet graphs for the fourth unit of the SINPO code, giving the values of the P figure for "propagation disturbance". The definitions of this figure and the interpretations placed on them in the log-sheets are as follows:

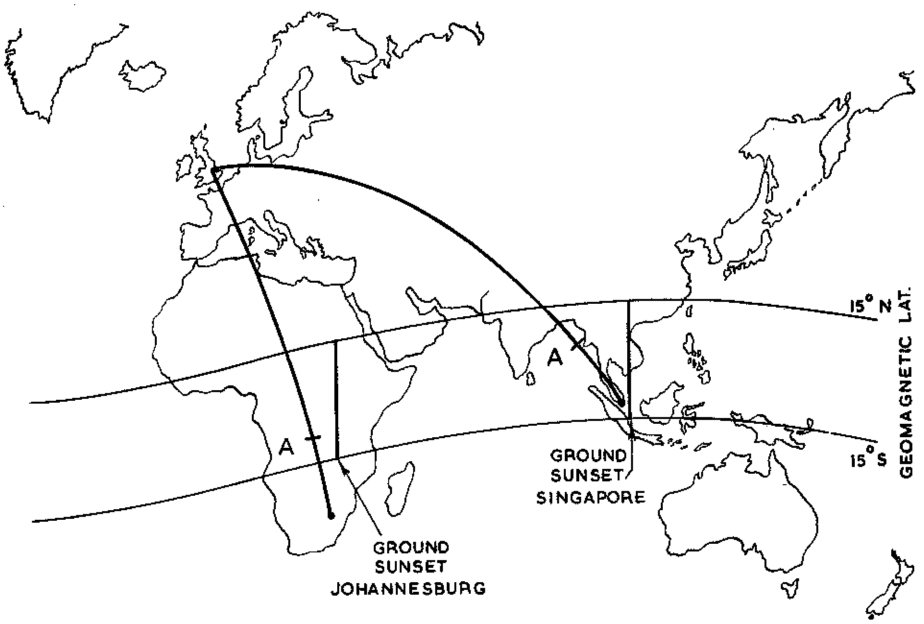
5 – Propagation disturbance nil – condition seldom present
4 – Propagation disturbance slight – normal slight fading
3 – Propagation disturbance moderate – medium rapid fading
2 – Propagation disturbance severe – deep rapid fading
1 – Propagation disturbance extreme – very deep rapid fading.

2.2. Handling of the Data

It was found that the tropical sunset fading effect appeared to be present when fading of the medium-rapid or worse types was observed, and the data were therefore analysed for each frequency at each hour in terms of the number of occasions when the P figure shown was 3 or less.

The map of Fig. 1 shows the great circle paths from the U.K. to Singapore and Johannesburg.

Singapore lies in approximately latitude 1° 17' N, longitude 103° 51' E, the bearing being approximately 77° from true north and the distance approximately 10,800 kilometres. The mean time of sunset for the equinoctial months is 1800 LT, which, if taken as that applicable to the 105th meridian, corresponds to 1100 GMT. The log-sheet data for the five-hour period 1100–1600 GMT were, therefore, used in the analysis, corresponding approximately to the period 1800–2300 LT.



A—SOUTHERN "CONTROL POINTS"

Fig. 1 - Great Circle transmission paths to Singapore and Johannesburg.

Johannesburg lies in approximately latitude 26° 10' S, longitude 28° 08' E, the bearing being approximately 153° from true north and the distance approximately 9,000 kilometres. The mean time of sunset for the equinoctial months is a few minutes after 1800 LT, which, taken as being 1800 LT on the 30th meridian, corresponds to 1600 GMT. The log-sheet data for the five-hour period 1600-2100 GMT were, therefore, used in the analysis, corresponding approximately to the period 1800-2300 LT.

The five-hour period examined was, therefore, that immediately following on ground sunset at both stations.

2.3. Presentation of Results

It was desired to present the results in a manner indicative of the general disruptive effect of tropical sunset fading upon the broadcasting service. In order to do this it was first of all necessary to ascertain whether there is any significant difference in the effect with frequency, since more than one frequency may be in use at any one time (in the case of Singapore three frequencies in one frequency-band may be employed simultaneously for different services). Furthermore, the frequencies in use may vary throughout the five-hour period, and are also changed from time to time to take account of seasonal and sunspot cycle variations.

The log-sheets were examined at each hour for every frequency which was in use over the two circuits during every day of each month for which data were available, and the total number of observations found for each hour. The number of occasions at each hour when the P figure was 3 or less was expressed as a percentage of the total hourly observations, when fading of the medium-rapid or worse types was present.

The frequency test mentioned above is shown in the graphs of Fig. 2, for both stations for the months of March and September 1957. These indicate that although, in general, the incidence of the fading at any one time is somewhat greater the higher the frequency, this effect is not very significant, and that when the fading is present it affects very appreciably all the frequencies in use. In view of this, it was considered valid to use the percentage of total hourly observations criterion as indicative of the incidence of the effect, irrespective of the actual frequencies in use.

3. DISCUSSION OF RESULTS

The results of the analysis are given in the graphs of Fig. 3 for both stations for the equinoctial months 1953-1958 inclusive. It should be mentioned that sunspot minimum occurred in April 1954 and thereafter sunspot activity increased to reach a maximum in March 1958.

3.1. Singapore

Fig. 3 shows that at Singapore the tropical sunset fading effect was not very much in evidence during 1953 and 1954, but that in March 1955 it was present, one hour after ground sunset, for about 28% of the total hourly observations. Thereafter its incidence increased with increasing sunspot number to reach values, two hours after sunset, during March and September 1958, of over 90% of the total hourly observations.

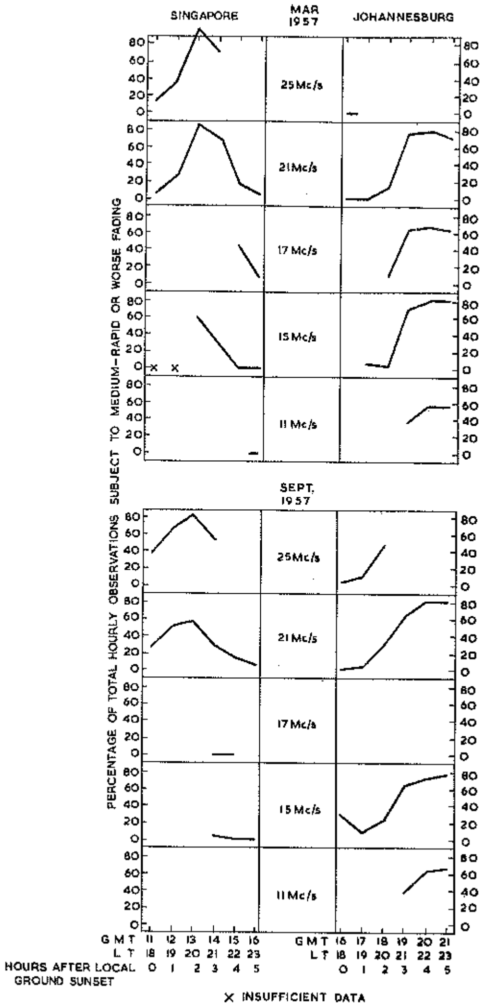


Fig. 2 - Incidence of medium-rapid or worse fading on different frequency bands - March and September 1957.

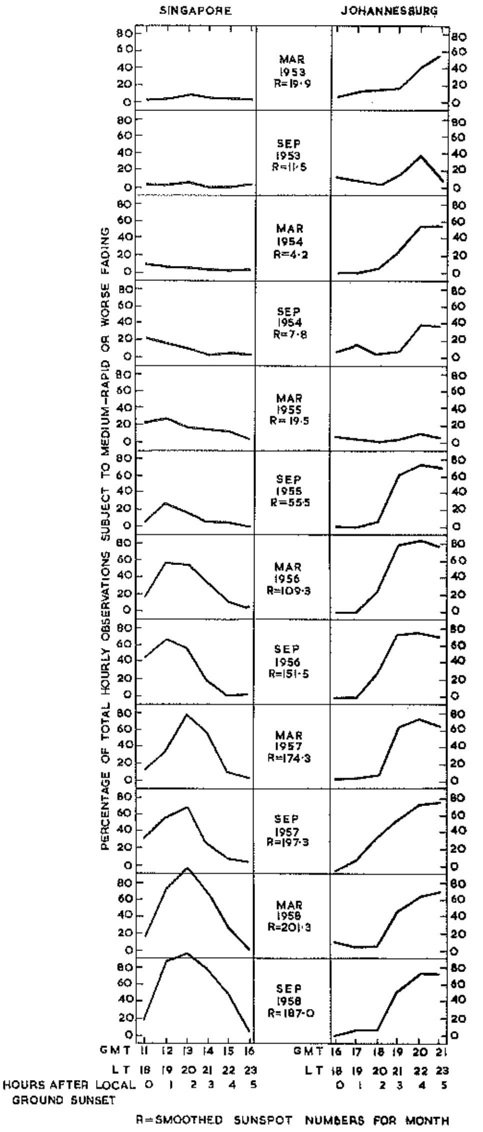


Fig. 3 - Incidence of medium-rapid or worse fading during the period 0 to 5 hours after ground sunset during equinoctial months 1953-1958.

During the years 1955–1958, when it was present, the time pattern in its incidence remained approximately the same, it being already present at sunset with an incidence of about 20% to 40% of total hourly observations, increasing sharply to reach a peak near two hours after ground sunset, and then decreasing sharply to reach values below 20% of total hourly observations usually by four hours after sunset, and always by one hour later than that. At 1600 GMT, five hours after sunset, the incidence of the fading was, in fact, always near 0% of the total hourly observations.

So far as the variation in the effect over the sunspot cycle is concerned, these results are in general agreement with those of Humby,[4] who showed that the effect became increasingly marked on the Singapore/London circuit from 1955 to 1958, and on the Colombo circuit from 1956 to 1958. They also agree, in general, with his results in the matter of the duration of the effect, which show, in the case of Singapore, that the effect, during the years when it is present, is most marked between about 1130 and 1500 GMT. The times indicated in Fig. 3 for Singapore are from about 1100 to 1500 GMT.

3.2. Johannesburg

The graphs of Fig. 3 indicate that, at Johannesburg, a substantially different state of affairs prevails.

In the first place they show that the fading was not entirely absent during the sunspot minimum years. It is true that in September 1954 and March 1955 its incidence was relatively low, and that it had much higher incidence values from 1956 to 1958. But even in 1953 and 1954 it was present, at the worst part of the period, for percentages of the total hourly observations of the order of 50.

What, however, is more remarkable is the complete difference in the time pattern of the fading from that shown for Singapore, and from that shown by the previous results quoted. At Johannesburg the tropical sunset fading effect does not, in fact, appear to start until, generally, two hours after ground sunset, and thereafter it appears to increase sharply in its rate of incidence, and to maintain this high incidence rate until at least five hours after sunset, after which there are no data available from the log-sheets, as Panorama closes down. But it is true to say that five hours after sunset, i.e. at 2100 GMT, there is little sign of a diminution in the incidence of the fading, this having been present at this time since September 1955 for from about 65% to 75% of the total hourly observations.

3.3. General

The tropical sunset fading effect thus appears to be most prevalent in broadcast reception at Singapore from local ground sunset until four hours thereafter, but at Johannesburg from two hours until five hours after local ground sunset, at which later time there is little sign of its clearing up. (It has been observed that signals from all European stations are more or less equally affected by it in Africa.) At Singapore, therefore, the incidence of the effect conforms approximately to the observations and predictions of Osborne, at least in that it is worst during the period 1900 to 2100 GMT, and also in its variations with increasing sunspot number. At Johannesburg it is different both in its diurnal time pattern and in its variations over the sunspot cycle. In particular, it is about two hours later in starting (in terms of Local Time), and persists for a greater time after sunset. Since this difference has persisted over so many years it can hardly be doubted that it is a true one, though it is very difficult to assign a reason for its occurrence. The following are mentioned as possibilities.

Assuming that the disturbed zone extends to at least ±15° of the geomagnetic equator, these limits have been marked on the map of Fig. 1, and the geographic meridians of 105° E and 30° E have been indicated as the ground sunset times at Singapore and Johannesburg, respectively.

If, on the Johannesburg circuit, the ground sunset time is taken for the most northerly point where the transmission path enters the disturbed ionospheric zone, and sunset in the F_2 layer is assumed to be one hour later than ground sunset, then sunset in the layer at this point is found to occur at approximately 1800 GMT, which is the time at which the fading is observed at Johannesburg. If the same thing is done for the most northerly disturbed point on the Singapore circuit, however, then sunset in the layer at this point is found to occur at approximately 1330 GMT, by which time the fading observed at Singapore has already passed its peak, and thereafter continues to decrease. Two possible explanations are as follows:

(i) The disturbed ionospheric zone is not symmetrical about the magnetic equator, but its northern boundary lies much nearer to the magnetic equator over the India/Burma/Malaya region than it does over Africa.

(ii) The actual trajectory followed by a wave received at Johannesburg is such as to impinge upon the F_2 layer at the extreme northern boundary of the disturbed ionospheric zone, whereas that followed by a wave received at Singapore is such as to avoid the northern part of the disturbed zone and only to reach the F_2 layer nearer the receiving point itself.

Such differences in the extent of the disturbed zone or in the propagation mechanism could account to some extent for the difference in the time of onset of the fading (in terms of local time) at the two places, but it is, of course, necessary to learn more about these phenomena before any definite conclusion can be reached.

4. SUGGESTION

In order to learn more about the effects of the phenomenon, and possibly to formulate methods whereby they might be avoided, it is suggested that more data about the nature and duration of the effect from different places from the north to the south of Africa might yield useful information.

5. CONCLUSIONS

(a) At Singapore, reception of B.B.C. transmissions was not much affected by the tropical sunset fading effect during 1953 and 1954, but from 1955 to 1958 the effect became increasingly noticeable as the sunspot number increased towards maximum. It took the form of medium-rapid or worse types of fading, at least during equinoctial months, which set in at ground sunset with an incidence of 20% to 40% of total hourly observations, increased to values up to 95% of total hourly observations one to two hours after sunset, and decreased to a negligible incidence rate four to five hours after sunset.

(b) At Johannesburg, reception of B.B.C. transmissions was affected by the tropical sunset fading effect even during sunspot minimum years, though its incidence was relatively low during September 1954 and March 1955. Thereafter it increased with increasing sunspot number towards 1958. It took the form of medium-rapid or worse types of fading, at least during equinoctial months, which did not usually reach an incidence rate of 20% of total hourly observations until two hours after ground sunset, but increased to values near 80% of total hourly observations at four hours after sunset, and showed little sign of decreasing its incidence rate five hours after sunset.

(c) Since the sunspot number is now decreasing it may be expected that the incidence rate for this phenomenon will decrease during the next few years, but may not reach negligible proportions at Singapore until about 1964.

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